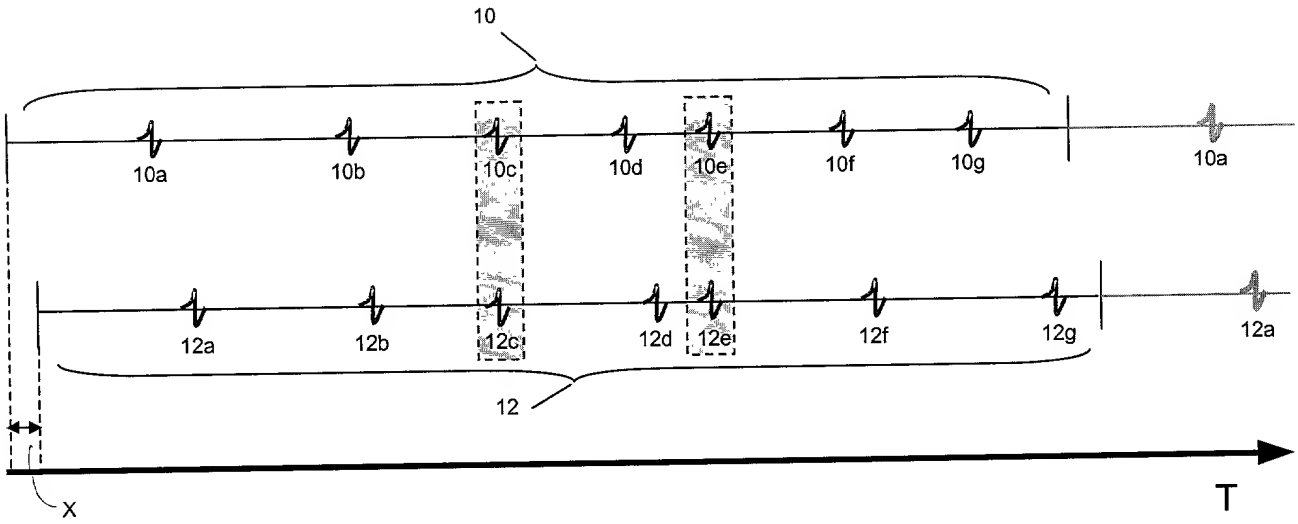

10
10a
10b
10c
10d
10e
10f
10g
10a
12a
12b
12c
12d
12e
12f
12g
12a
12
X
T

FIG. 1

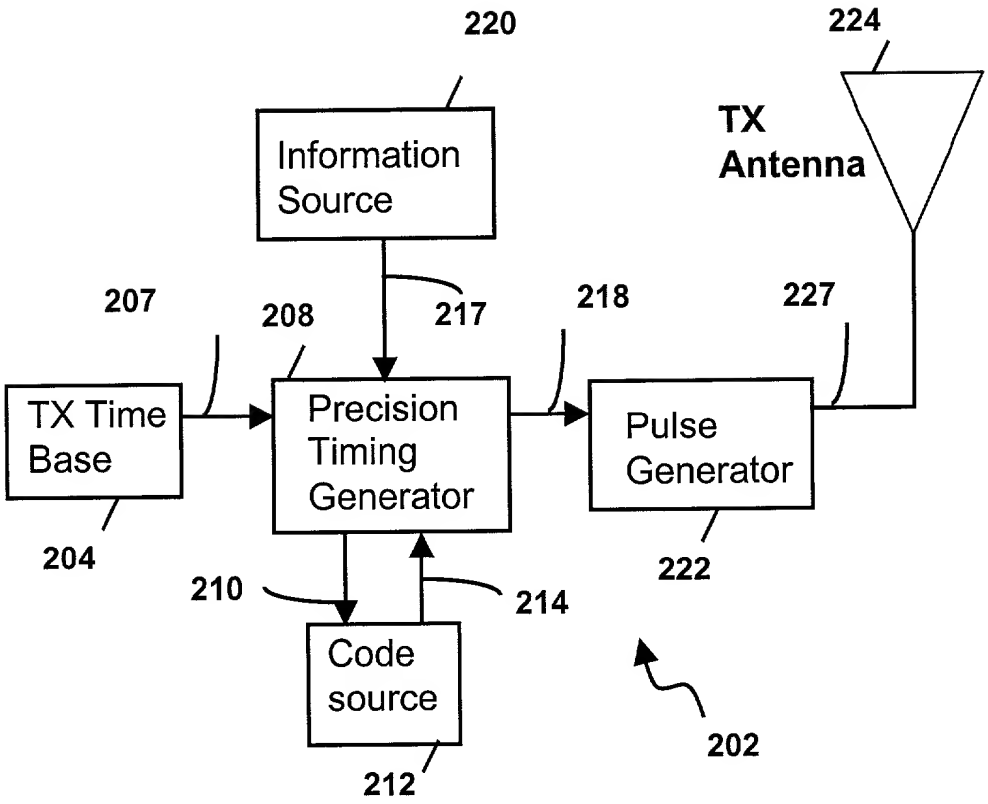

220
224
Information Source
TX Antenna
207
208
217
218
227
TX Time Base
Precision Timing Generator
Pulse Generator
204
222
210
214
Code source
202
212

FIG. 2

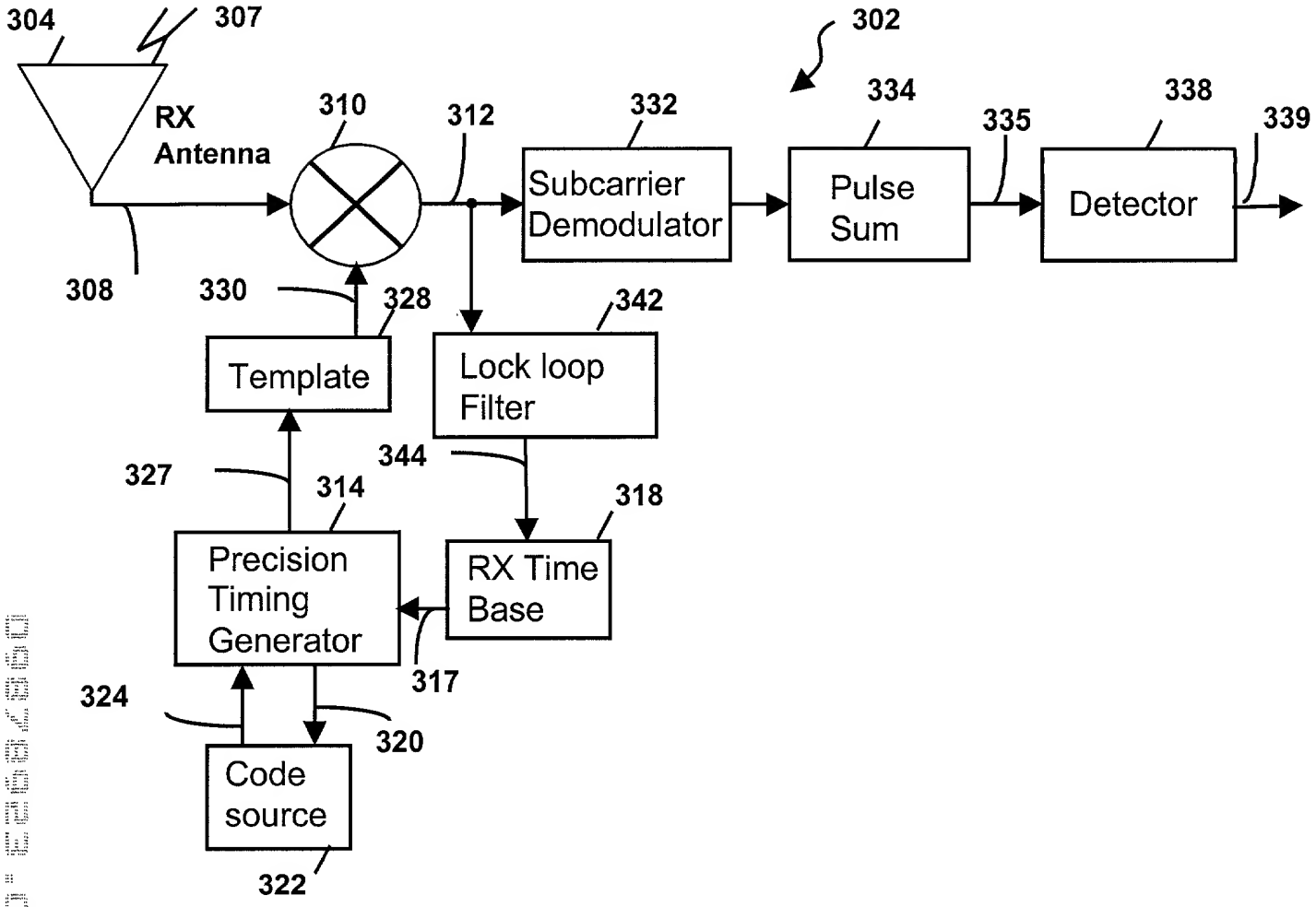

304
307
302
RX
Antenna
310
312
332
334
335
338
339
Subcarrier
Demodulator
Pulse
Sum
Detector
308
330
328
342
Template
Lock loop
Filter
344
327
314
318
Precision
Timing
Generator
RX Time
Base
317
324
320
Code
source
322

FIG. 3

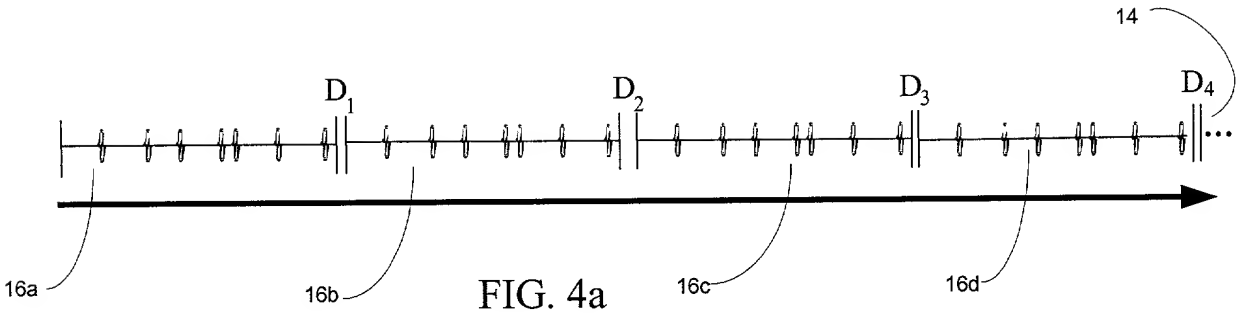
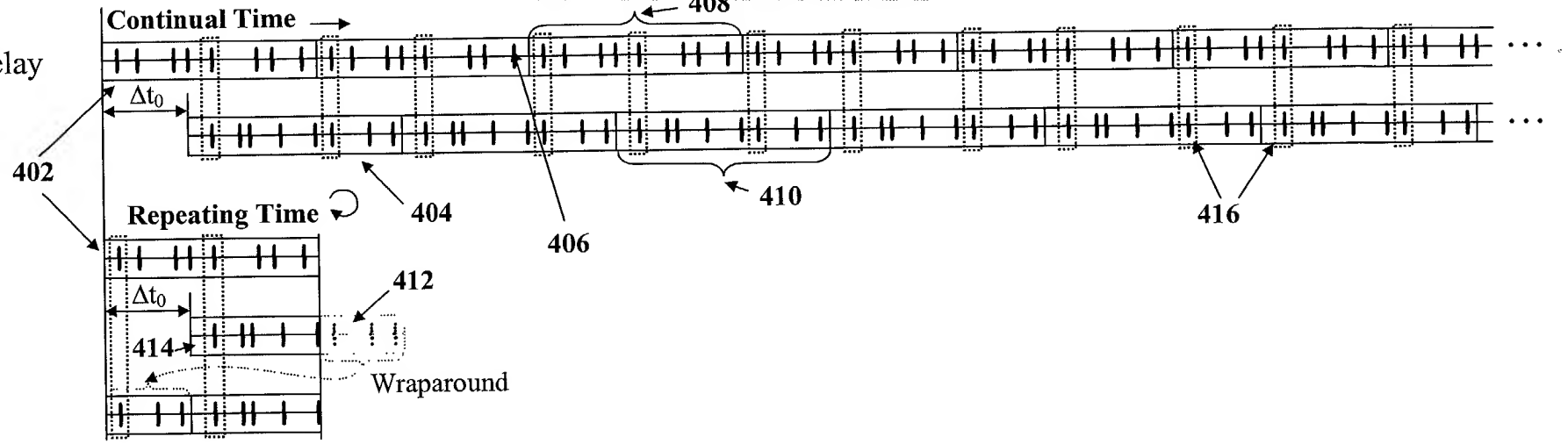


FIG. 4a

Example 1:
Without Delay
Code



Example 2:
With Delay
Code

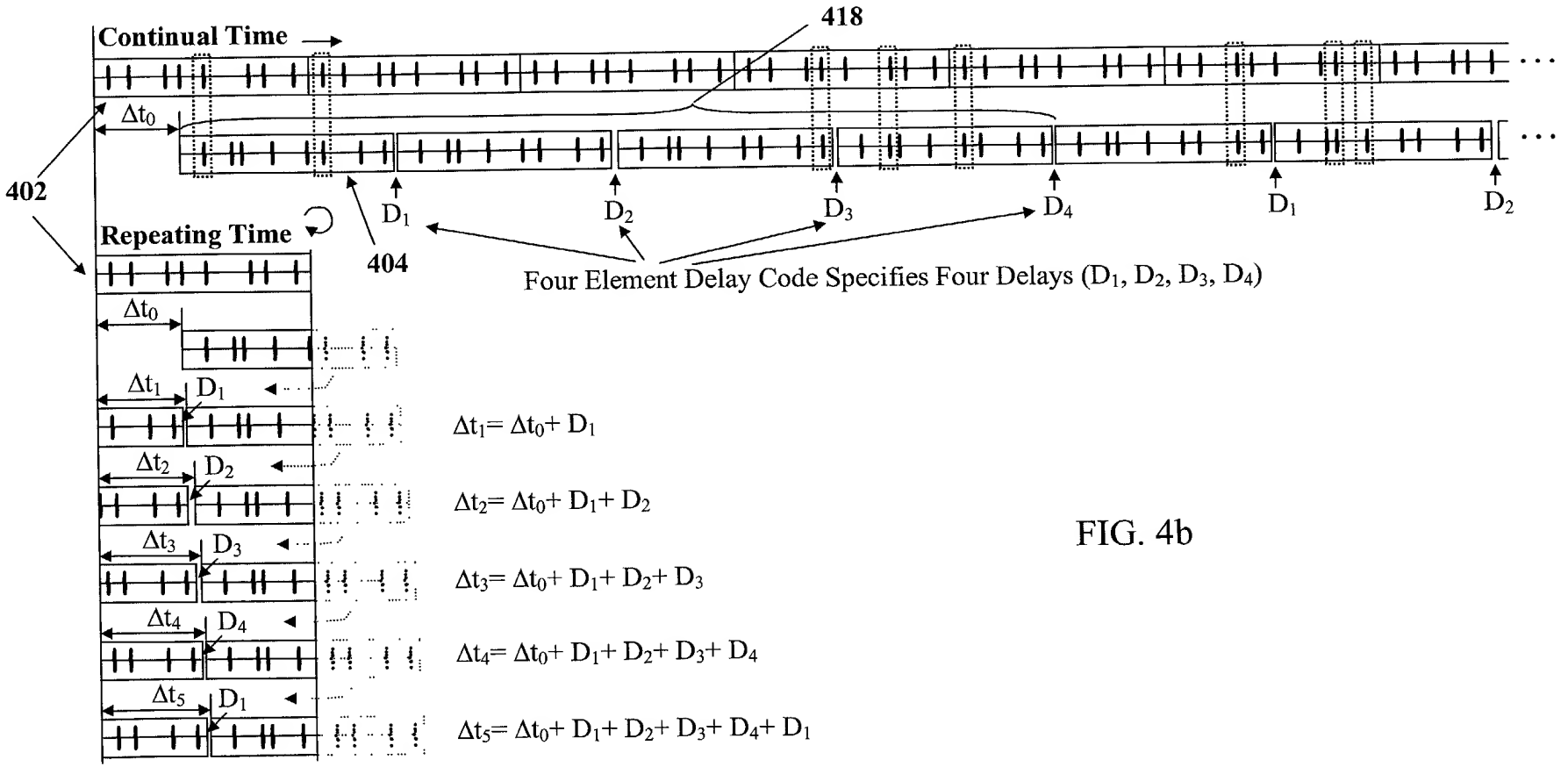


FIG. 4b

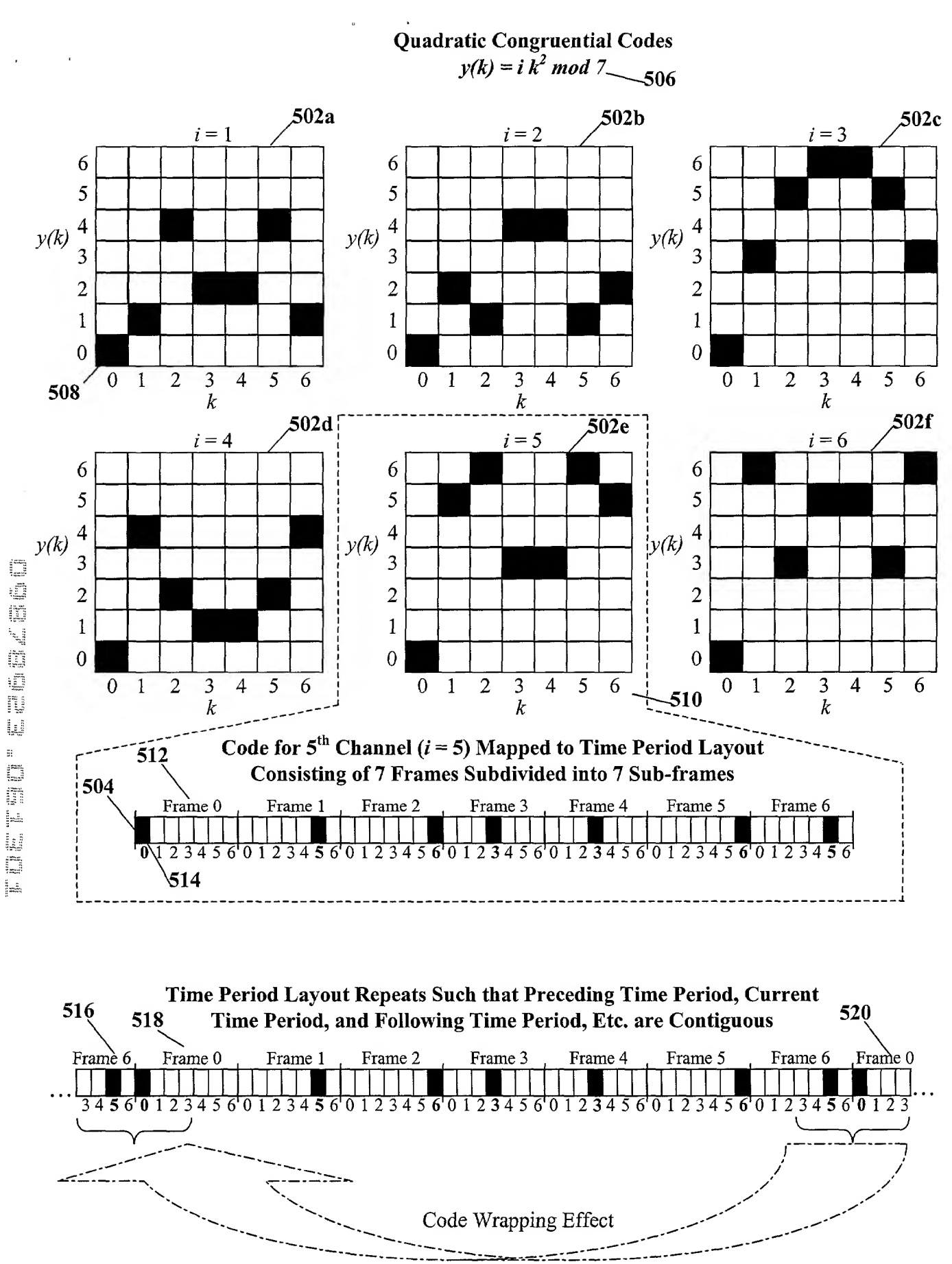

Quadratic Congruential Codes
y(k) = i k^2 mod 7
506
502a
i = 1
502b
i = 2
502c
i = 3
502d
i = 4
502e
i = 5
502f
i = 6
y(k)
k
508
510
Code for 5th Channel (i = 5) Mapped to Time Period Layout
Consisting of 7 Frames Subdivided into 7 Sub-frames
512
504
514
Frame 0
Frame 1
Frame 2
Frame 3
Frame 4
Frame 5
Frame 6
Time Period Layout Repeats Such that Preceding Time Period, Current
Time Period, and Following Time Period, Etc. are Contiguous
516
518
520
Code Wrapping Effect

FIG. 5

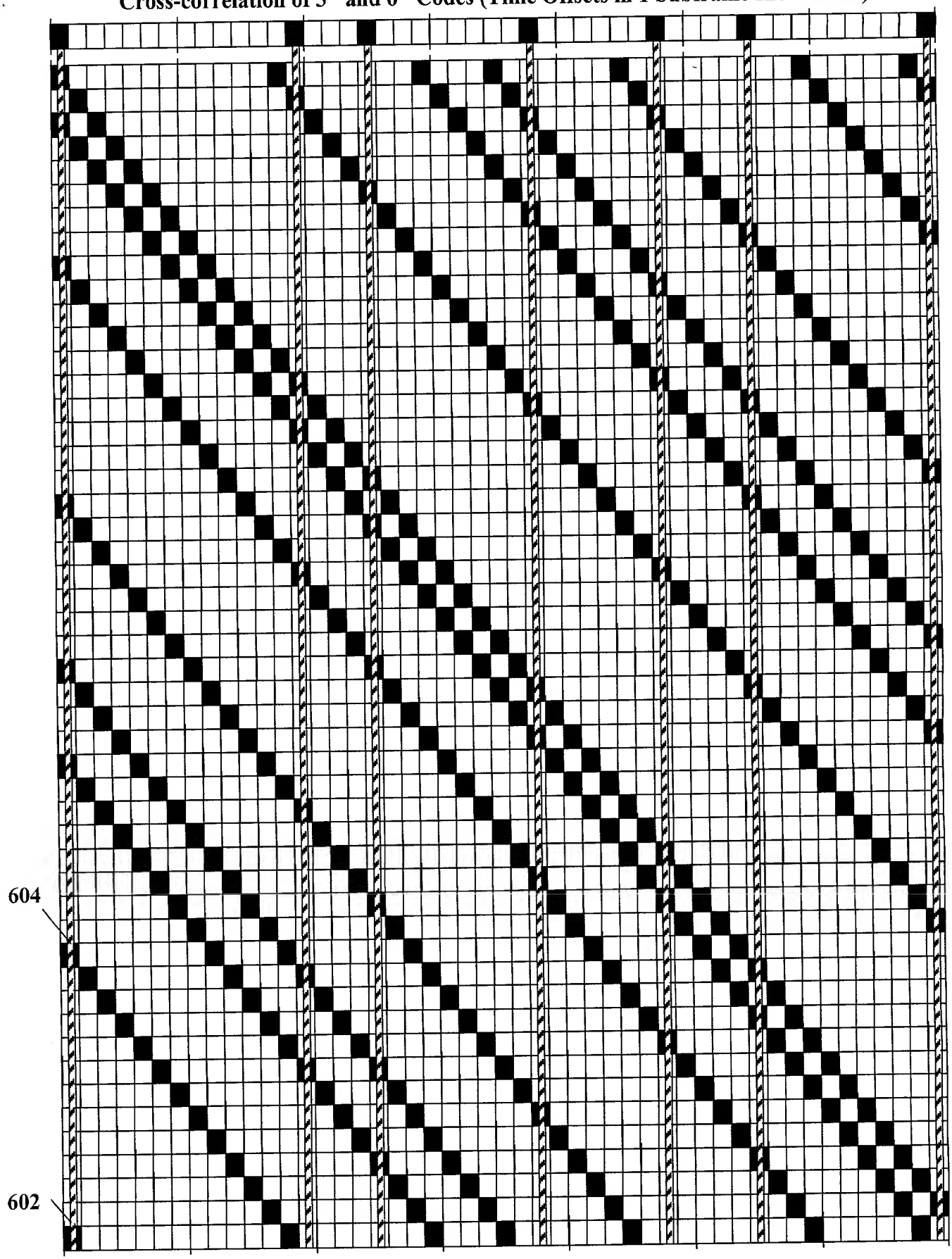

Cross-correlation of 5th and 6th Codes (Time Offsets in 1 Subframe Increments)
604
602

FIG. 6

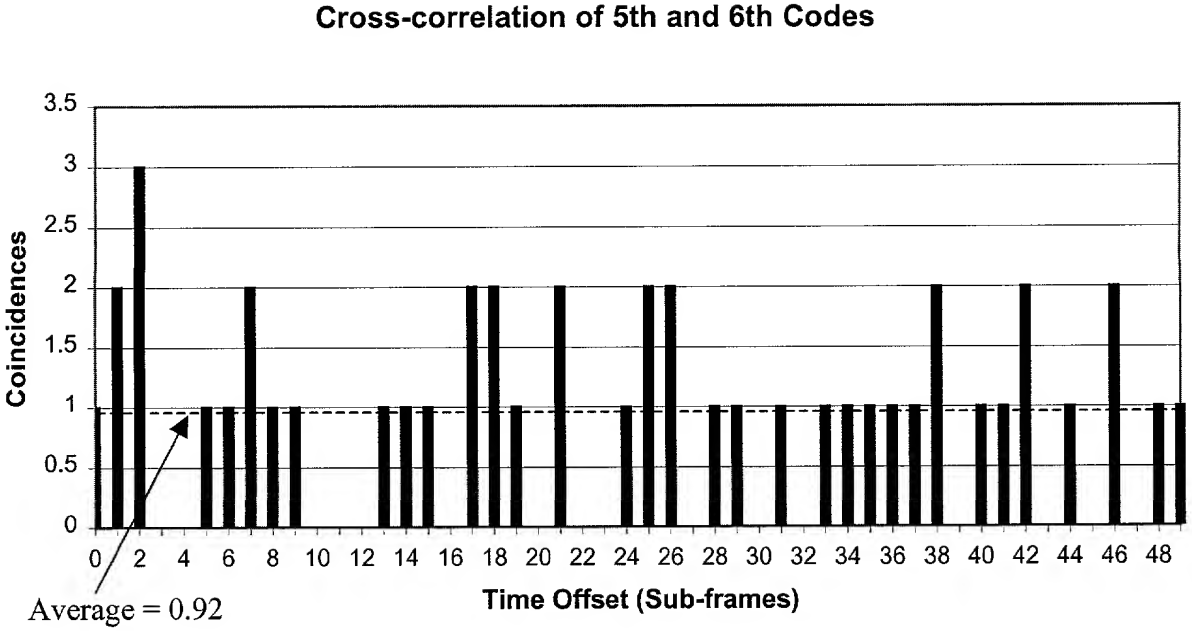

Cross-correlation of 5th and 6th Codes
Coincidences
3.5
3
2.5
2
1.5
1
0.5
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48
Time Offset (Sub-frames)
Average = 0.92

FIG. 7

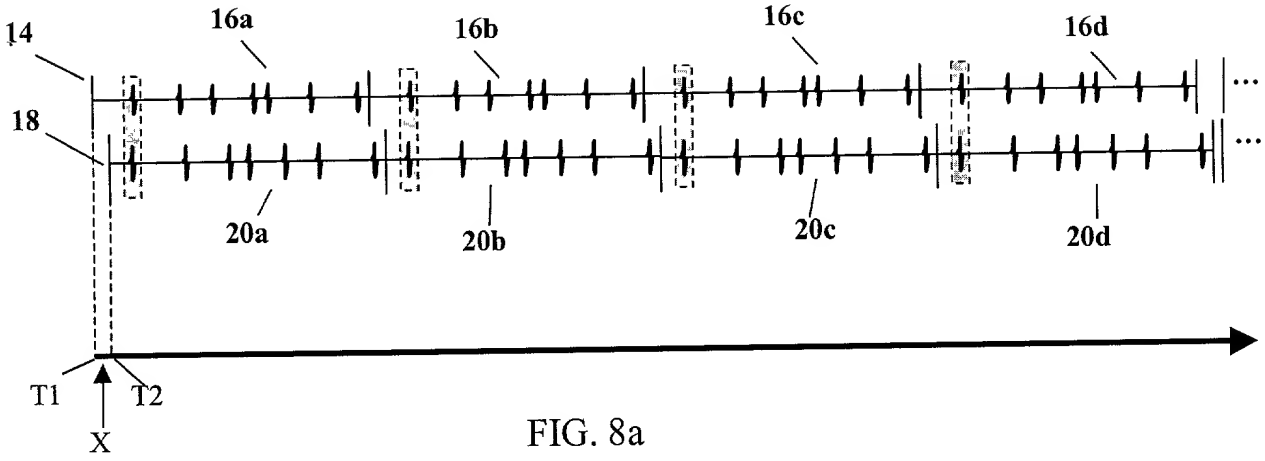

14
16a
16b
16c
16d
18
20a
20b
20c
20d
T1
T2
X

FIG. 8a

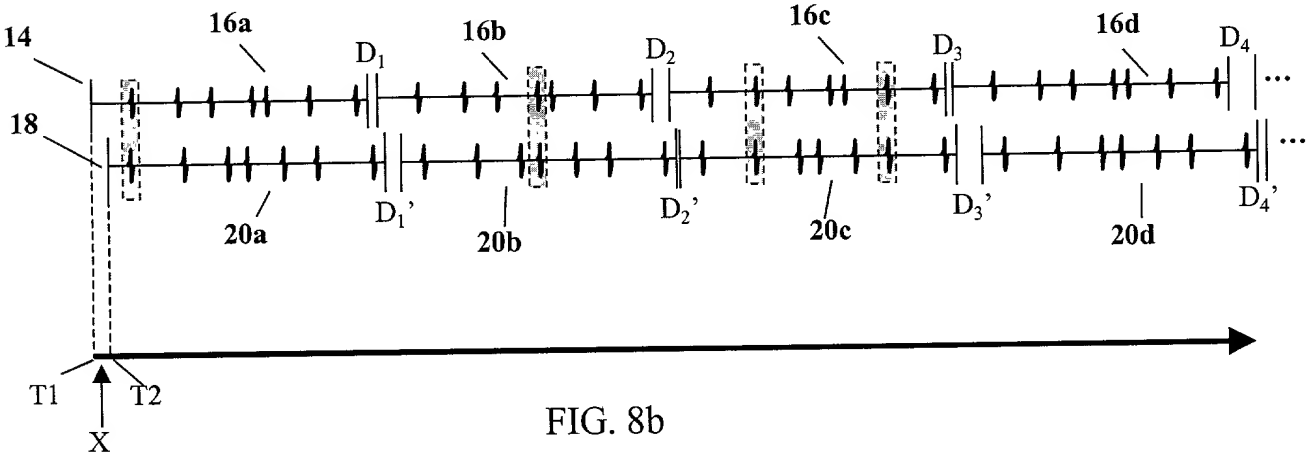

14
16a
16b
16c
16d
18
D1
D2
D3
D4
D1'
D2'
D3'
D4'
20a
20b
20c
20d
T1
T2
X

FIG. 8b

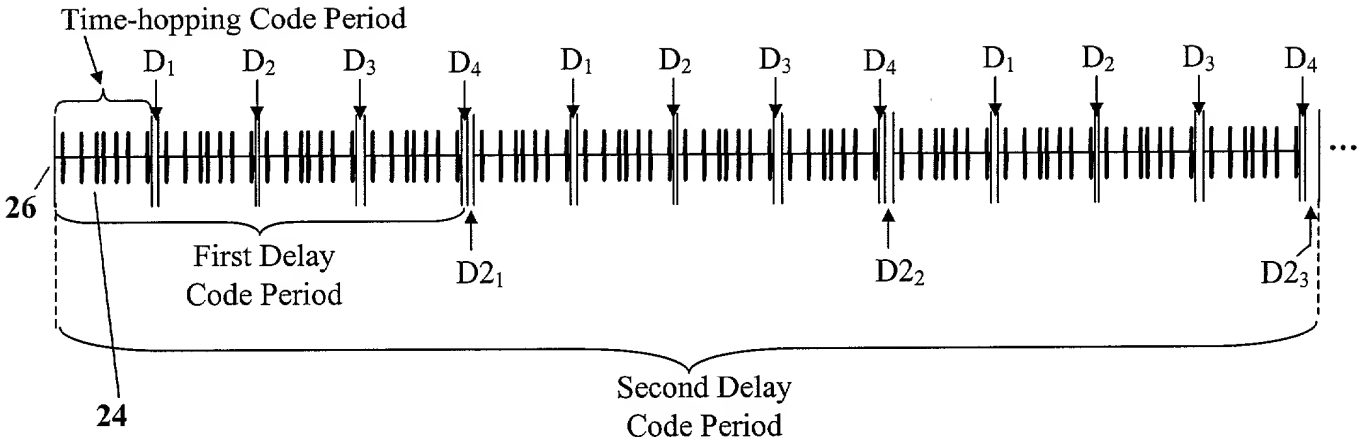
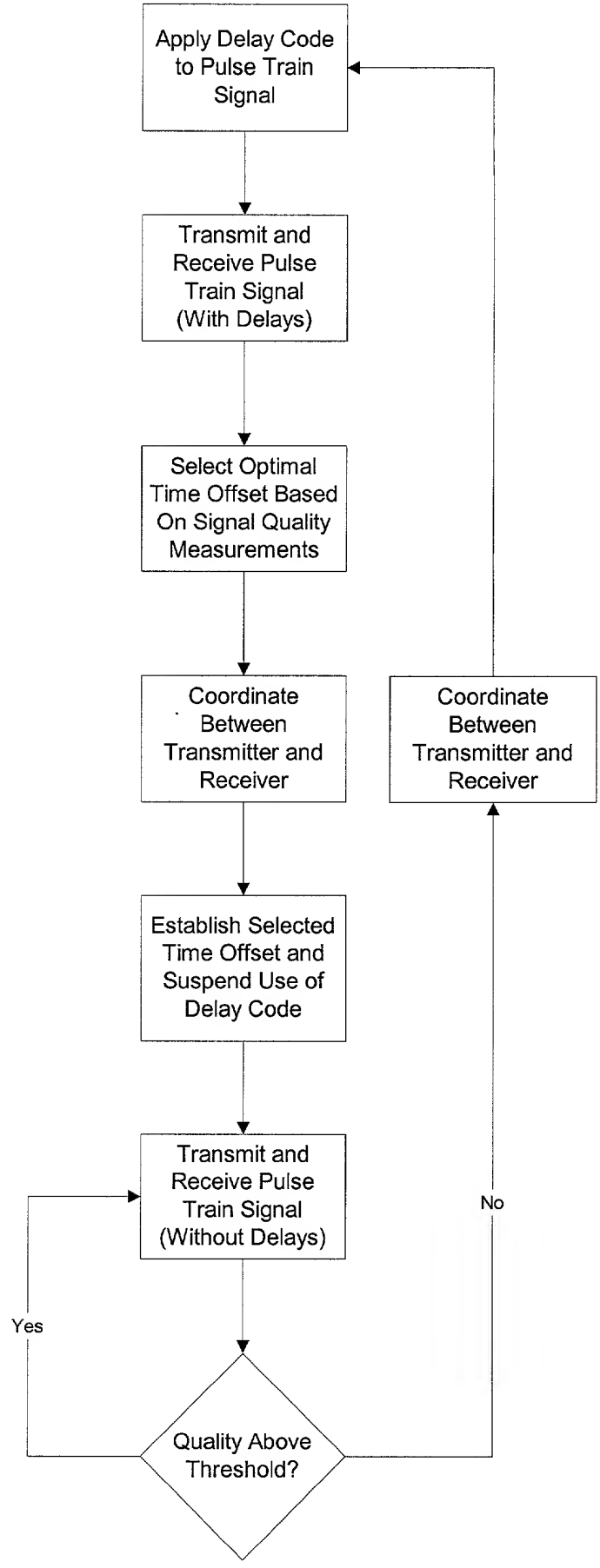

Time-hopping Code Period
D1
D2
D3
D4
D1
D2
D3
D4
D1
D2
D3
D4
...
26
First Delay
Code Period
D21
D22
D23
24
Second Delay
Code Period

FIG. 9

FIG. 10


Apply Delay Code to Pulse Train Signal
Transmit and Receive Pulse Train Signal (With Delays)
Select Optimal Time Offset Based On Signal Quality Measurements
Coordinate Between Transmitter and Receiver
Coordinate Between Transmitter and Receiver
Establish Selected Time Offset and Suspend Use of Delay Code
Transmit and Receive Pulse Train Signal (Without Delays)
No
Yes
Quality Above Threshold?